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Influence of Student Beliefs about Nature of School Mathematics on their Achievement at Secondary Level in Kerala

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Abstract

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This study probes students' beliefs about nature of mathematics, difficulty in learning mathematics sourcing from these and their influence on achievement in mathematics. Questionnaire survey on 458, 9th standard students randomly selected from schools of Malappuram district elicited data on nature of school mathematics and difficulty arising out of it. Test on Achievement of Prerequisites in Mathematics on Basic operations, Rational numbers and exponents, Geometry, Algebra, and Daily Mathematics was conducted. Overall achievement in mathematics and achievement in its component areas are influenced more by difficulties arising from nature of content than teaching learning process and learning technique. Achievement in daily mathematics is influenced by difficulties arising out of teaching learning process. Findings implies that special nature of mathematics is to be considered in adapting teaching learning to reduce difficulties in learning it.

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National Curriculum Framework 2015 has envisioned the aim of mathematics education as to develop the child's resources to think and reason mathematically, to pursue assumptions to their logical conclusion and to handle abstraction. It includes a way of doing things, and ability and attitude to formulate and solve problems (NCF 2005). Even though mathematics has been given due importance in school curriculum, large number of children dislikes mathematics and felt it as the most difficult subject in schools. National achievement survey 2015 found that 48% of students in 10th standard of Kerala were in 0-35% scores, 29 % students were in 36-50% scores and only 2% of students scored above 75% in Mathematics. ASER report 2014 also found dropping achievement in basic arithmetic skills of primary students. The student difficulty in learning and achieving in mathematics is attributed to many factors.

Papanastasiou (2000) identifies both internal factors like content of the test, quality of items, linguistic factors and external factors like environment of the learner to affect performance of the students in test situations. Curricular materials, gap between learner and subject matter, memory ability, attention span and understanding the language of mathematics are also cited (Sherman, Richardson & Yard, 2014) as major reasons for students falling below their expected level of mathematics achievement. One of the major categories of reason for students feeling difficulty to learn various subjects are related to the nature and characteristics of the content and method of respective subject (Gafoor & Sarabi, 2015a). Mathematics unlike other subjects has number of factors, which makes the subject peculiar in nature. Cumulative effect of these factors related to its nature makes mathematics difficult to learn.

Belief about nature of mathematics has been identified as a major factor influencing mathematics learning. Number of studies has been focused on Students beliefs about nature of mathematics and its influence on different aspects of mathematics learning. Mathematical ability is significantly correlated with students' belief about importance of mathematics and belief about own ability in mathematics and self-regulated learning (Suthar & Khooharo, 2013; Suthar, Tarmizi, Midi & Adam, 2010). Students' belief about mathematics influences



mathematical self-efficacy, which in turn influences achievement in mathematics (Kamalimoghaddam, Tarmizi, Ayub & Jaafar, 2016). Students' conception of mathematics and their approach in learning Mathematics are related. Students who conceived mathematics as numbers, rules and formula learn mathematics by rote memorization. Students who conceive mathematics as a way of thinking learn mathematics by doing examples to develop relational understanding and to extend understanding (Crawford, Gordon, Nicholas & Prosser, 1994). Gafoor and Sarabi (2015b) compared perception of difficulty in learning mathematics with other school subjects based on 13 reasons emerging from nature of mathematics. All characteristics except the factor uselessness in daily life are perceived as making mathematics difficult to learn than other non-language subjects. Perceived difficulty in mathematical tasks is found to relate to factors sourcing from nature of mathematics (Gafoor & Sarabi, 2015c). Hence, this study builds upon the previous ones (Gafoor & Sarabi, 2015b, 2015c) in examining the belief about nature of mathematics, which makes it difficult to learn, and the influence of such factors, if any, on the difficulty in achieving select areas of secondary school mathematics.

Eynde, Corte, and Verschaffel (2002) put forward a framework of students Mathematics related beliefs with three major components viz. Beliefs about mathematics education, Beliefs about the self and Beliefs about the social context. Beliefs about mathematics education concerns with a) Belief about mathematics as a subject, b) Belief about mathematics learning and problem solving and c) Belief about mathematics teaching in general. Beliefs about the self, concerns with Self-efficacy beliefs, Control beliefs, Task value beliefs and Goal orientation beliefs. Beliefs about social norms and sociomathematical norms in their own class are included in beliefs about the social context. This study pertains more with the belief about Mathematics education.

Belief about nature of mathematics studied here, concern more about the belief about difficulties sourcing from nature of mathematics. Here in, difficulty in achieving is defined as the failure to achieve essential concepts and skills the students learned in previous grades and are prerequisites for learning in the present grade level.

Research questions

1. How difficult are students rating Mathematics in relation to other school subjects including languages? Do secondary students have difficulty in achieving prerequisites in Mathematics? If so, how much students achieve in select areas of secondary school maths?
2. Do student perception of Mathematics as a difficult subject relates to their perception of nature of Mathematics? What are the broad categories of characteristics of school mathematics as students perceive it?
3. Do such factors in nature of Mathematics contribute significantly to student achievement of prerequisites in secondary school Mathematics? To what extent factors in nature of Mathematics influence achievement in the select areas of secondary school maths?

Method

Participants

Participants were 458, 9th standard students randomly selected from government and aided schools of Malappuram district with equal weightage to gender of the student from urban and rural area.

Research Instruments

1. Questionnaire on Factors affecting Mathematics Learning: This is a revised version of Questionnaire on Factors affecting Mathematics Learning prepared for an earlier phase of this study (Gafoor & Sarabi, 2015b). The new version contains 13 items. First item was to rate the school subjects viz. Malayalam I, Malayalam II, English, Hindi, Physics,



Chemistry, Biology, Mathematics, Social Science and IT in the order of feeling of difficulty. Remaining 12 items contains reasons related to nature of school mathematics that makes the subject difficult to learn. The reasons included are Uselessness in daily life, Rote learning, Prevalence of symbols and notations, Need to learn unfamiliar terms, Understanding questions, Need for external support, Toughness of concepts, Number of concepts, Repeated Practice, Need for strenuous attention, Need for unfaltering Regularity in attending classes and Need for Precision in understanding. Participants have to rate their feeling of difficulty of mathematics sourcing from each of these reasons.

2. Test on Achievement of Prerequisites in Mathematics for Grade 9 (Mumthas, 2016): This test is developed for measuring Prerequisite achievement in Mathematics among secondary school students (Mumthas, 2016). With items on concepts in lower grades, it tests achievement of prerequisites for learning mathematics concepts in Grade 9. The areas included in the test are Basic operations, Rational numbers and exponents, Geometry, Algebra, and Daily Mathematics. Sixty items were included in the test. Maximum score that can be obtained was 60. The test score has high positive correlation with scores obtained on achievement in grade 9 maths tested by the schools ($r=.71$, $N=374$, $p<.01$)

Results and Discussion

Mathematics is comparatively highly difficult subject as perceived by the students. Prerequisite achievement in Mathematics and its component areas are not at satisfactory level. Number of factors were identified as the reason for difficulty in learning Mathematics.

Results are discussed under the major headings viz. *Comparison of difficulty level of Mathematics with other school subjects as perceived by students, Prerequisite achievement in Mathematics, Level of Perceived Reasons for difficulty in learning Mathematics, Structure of reasons for difficulty, Relation between Nature of school Mathematics and Perceived Difficulty in learning Mathematics and Influence of Nature of school Mathematics on student achievement of prerequisites in school Mathematics.*

I. Comparison of student perception of difficulty in Mathematics with other school subjects

The perceived difficulty of school subjects among 9th Standard students seems to be in the order Mathematics, Hindi, English, Physics, Social Science, Chemistry, Biology, IT, Malayalam I, Malayalam II. The mean scores of perceived difficulty of other subjects are put alongside and compared with that of Mathematics in table 1.



Table 1

Results and Descriptive Statistics for Paired t -test of Perception of Difficulty of School Subjects

<u>Mathematics</u>		<u>Comparison subject</u>				
M	SD	Subject	M	SD	r	t
2.47	.637	Hindi	2.17	0.62	.003	6.94**
		English	2.06	0.6	.136**	9.77**
		Physics	1.99	0.64	.273**	11.96**
		Social Science	1.90	0.59	.130**	14.06**
		Chemistry	1.82	0.65	.276**	16.64**
		Biology	1.58	0.59	.089	20.99**
		IT	1.48	0.61	-.002	22.11**
		Malayalam I	1.37	0.54	-.118*	26.05**
		Malayalam II	1.31	0.52	-.076	27.51**

* $p < .05$. ** $p < .01$ (Note: N= 458)

Mathematics is perceived as more difficult in comparison to all other subjects namely Hindi ($r=.003$, $t=6.94$, $p<.01$), English ($r=.136$, $t=9.77$, $p<.01$), Physics ($r=.273$, $t=11.96$, $p<.01$), Social Science ($r=.130$, $t=14.06$, $p<.01$), Chemistry ($r=.276$, $t=16.64$, $p<.01$), Biology ($r=.089$, $t=20.99$, $p<.01$), IT ($r=-.002$, $t=22.11$, $p<.01$), Malayalam I ($r=-.118$, $t=26.05$, $p<.01$) and Malayalam II ($r=-.076$, $t=27.51$, $p<.01$).

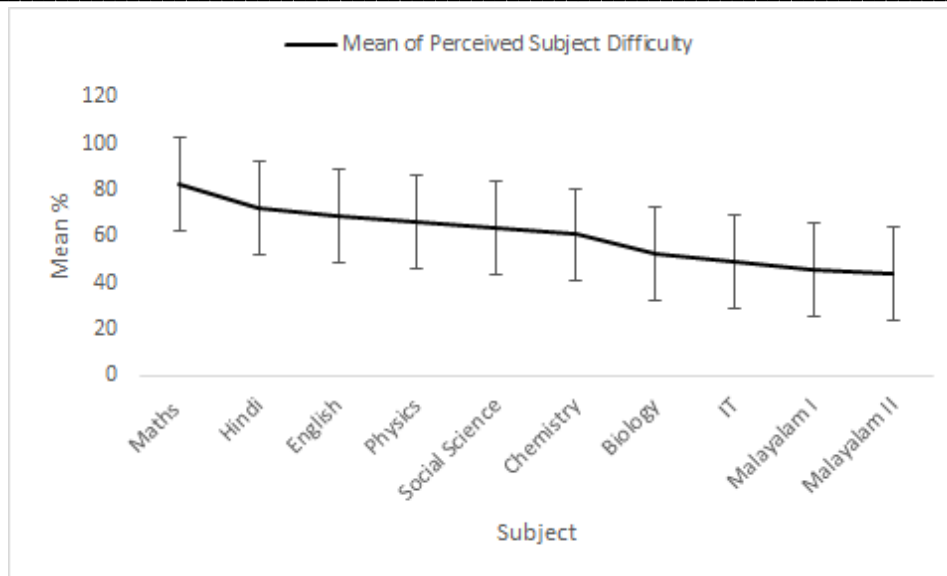


Figure 1: Extent of student perception of difficulty in secondary school subjects

II. Extent of achievement of Prerequisites in Mathematics among secondary students

Twenty-five percent of students have acquired only 1/3rd of the prerequisite achievement in Mathematics and more than 50% fails to acquire half of the pre requisite for learning Mathematics in standard nine. The mean scores of achievement in these five areas of school Mathematics appears in the order Basic operations, Daily Mathematics, Geometry, Rational Numbers & exponents and Algebra. Mean percent scores of Prerequisite achievement in different areas of Mathematics is given in table 2.

Table 2

Mean percent Score of Prerequisite Achievement in Mathematics among Grade 9 Students in Kerala

Topic	Mean (% score)	SD
Basic operations	55	20
Daily Mathematics	55	23
Geometry	51	19
Rational Numbers & exponents	40	21
Algebra	39	24
Total	48	18

Students have less than satisfactory level of Prerequisite achievement in Mathematics (Mean%=48). In addition, students' achievement in areas like Rational numbers & exponents (Mean%=40) and algebra (Mean%=39) are below 50%. In other areas like Basic operations (Mean%=55), Daily Mathematics (Mean%=55) and Geometry (Mean%=51) also achievement



cannot be considered satisfactory. Since the test was based on prerequisites for learning mathematics concepts in Grade 9 constructed based on concepts in lower grades these levels of achievement is deficient.

III. Level of Perceived Reasons for difficulty in learning Mathematics

Reasons for difficulty in learning Mathematics sourcing from nature of Mathematics were rated. Mean percent index of difficulty sourcing from Nature of Mathematics as perceived by students is given in table 3.

Table 3

Mean percent index of difficulty due to reasons sourcing from Nature of Mathematics as perceived by students

Reasons for difficulty	Mean%	SD
Need for Regularity in Attending Classes	87.33	19.66
Toughness of concepts	82.67	22.00
Need for external support	77.00	21.67
Number of concepts	74.33	23.67
Need for rote learning	73.33	22.67
Need for Precision in understanding	72.67	23.00
Need to learn unfamiliar terms	68.67	24.00
Need for Strenuous attention	68.00	24.67
Need for Repeated Practice	67.33	22.33
Difficulty in understanding questions	67.00	24.33
Uselessness in daily life	64.33	25.67
Prevalence of symbols and notations	63.67	25.00

Note. N= 458

All the 12 identified components of nature of Mathematics cause difficulty in learning Mathematics. Difficulty sourcing from need for regularity in attending classes (Mean%=87.33) is the major factor. Difficulty sourcing from other factors are in the order- toughness of concepts (Mean%=82.67), need for external support (Mean%=77), number of concepts (Mean%=74.33),



need for rote learning (Mean%=73.33), need for precision in understanding (Mean%=72.67), need to learn unfamiliar terms (Mean%=68.67), need for strenuous attention (Mean%=68), need for repeated practice (Mean%=67.33) and difficulty in understanding questions (Mean%=67). Difficulty sourcing from uselessness in daily life (Mean%=64.33) and prevalence of symbols and notations (Mean%=63.67) are less indexed.

IV. Structure of Reasons for difficulty in learning Mathematics sourcing from nature of school Mathematics

Factorability of 12 reasons for difficulty in learning Mathematics sourcing from nature of mathematics was examined. The results of factor analysis are summarized in table 4.

Table 4

Rotated Component Matrix showing Factor Structure of Reasons for Difficulty in Learning Mathematics Sourcing from Nature of School Mathematics

Reasons for difficulty	<u>Components</u>		
	Nature of content	Teaching learning process	Learning techniques
Number of concepts	.73		
Prevalence of symbols and notations	.60		
Difficulty in understanding questions	.60		
Toughness of concepts	.60		
Need to learn unfamiliar words	.56		
Uselessness in daily life		.69	
Need for Strenuous attention		.65	
Need for Regularity in Attending Classes		.55	
Need for external support		.50	
Need for Precision in understanding		.44	
Need for rote learning			.81
Need for Repeated Practice			.74

Principal component analysis revealed three factors. The first factor *Nature of Mathematics content* explained 19.73 % variance, second factor *Teaching Learning Processes* explained 18.13% of variance and the third factor *Learning Techniques* explained 13.82% variance. The 3-factor solution explained 51.68% total variance.

Reasons for difficulty sourcing from Nature of Mathematics content (with corresponding factor loading) are Number of concepts (0.73), Prevalence of symbols and notations (0.60), Difficulty in understanding questions (0.60), Toughness of concepts (0.60) and Need to learn unfamiliar words (0.56). Reasons for difficulty sourcing from the factor teaching learning process are Uselessness in daily life (0.69), Need for Strenuous attention (0.65), Need



for Regularity in Attending Classes (0.55), Need for external support (0.50) and Need for Precision in understanding (0.44). Reasons for difficulty sourcing from the factor learning techniques are need for rote learning (0.81) and need for Repeated Practice (0.74).

Students perceive significantly more difficulty from Teaching learning Process of Mathematics (Mean=2.22, SD=0.46) than from Nature of content (Mean= 2.14, SD=0.49) in learning Mathematics [$r = .57$, $t=4.01$, $p<.01$]. Students perceive significantly more difficulty from Nature of content in learning Mathematics (Mean= 2.14, SD=0.49) than difficulty from learning techniques (Mean=2.11, SD=0.59) [$r=.38$, $t=4.07$, $p<.01$]. However, Difficulty in learning Mathematics sourcing from Teaching learning Process (Mean=2.22, SD=0.46) and learning technique (Mean=2.11, SD=0.59)[$r=.41$, $t=1.12$, $p>.05$] do not differ significantly.

V. Relation between Belief about Nature of school Mathematics and Perceived Difficulty in learning Mathematics

Belief about nature of school mathematics has significant positive correlation with perceived difficulty in learning mathematics. Correlation of belief about nature of mathematics and its factors with perceived difficulty in learning mathematics is given in table 5.

Table 5

Correlation of Belief about Nature of school Mathematics and its factors with Perceived Difficulty in learning Mathematics

Belief about Nature of school Mathematics	Perceived Difficulty in learning Mathematics
Nature of content	.256*
Teaching learning process	.291**
Learning technique	.116*
Nature of school Mathematics	.293**

* $p < .05$. ** $p < .01$

What students believe about nature of school mathematics ($r=.293$, $p<.01$) has significant positive low correlation with their perception of difficulty in learning it. The three factors of nature of school Mathematics have significant positive correlation with Perceived Difficulty in learning Mathematics. Both Nature of content ($r=.256$, $p < .05$) and Teaching learning process ($r=.291$, $p<.01$) have significant positive low correlation with Perceived Difficulty in learning Mathematics whereas Learning technique ($r=.116$, $p<.05$) has significant positive but negligible correlation with Perceived Difficulty in learning Mathematics.

VI. Influence of Belief about Nature of school Mathematics on student achievement of prerequisites

The influence of three factors of Nature of school Mathematics with their relative weights on achievement of prerequisites in mathematics in total and the five select areas of mathematics were estimated through six separate stepwise multiple regression analyses. The results are summarised in table 6.

Table 6

Results of Stepwise Multiple Regression Analyses of Belief about Nature of School Mathematics for Dependent Variables - Achievement of Prerequisites in Mathematics in total and its five select areas among Secondary School students

Dependent Variable	Predictors	R	R ² x 100	F	B	t	SE	β	r	$\beta \times r$
Achievement in	Prerequisites in Mathematics	0.28	8.2	19.95	-4.12	-3.84	1.07	-0.191	-0.252	0.048
	Learning technique				-2.7	-2.99	0.9	-0.148	-0.225	0.033
									$\Sigma \beta \times r$	0.081
	Basic Operations	0.31	9.3	22.93	-0.08	-4.09	0.02	-0.202	-0.268	0.054
	Learning technique				-0.06	-3.24	0.017	-0.16	-0.243	0.039
									$\Sigma \beta \times r$	0.093
Achievement in	Daily Mathematics	0.19	3.7	17.09	-0.09	-4.13	0.023	-0.192	-0.192	0.036
	Teaching learning process									
									$\Sigma \beta \times r$	0.036
	Algebra	0.25	6	14.33	-0.08	-3.36	0.024	-0.169	-0.219	0.037
	Learning technique				-0.05	-2.43	0.02	-0.122	-0.191	0.023
									$\Sigma \beta \times r$	0.06
Achievement in	Geometry	0.23	5	11.91	-0.064	-3.15	0.02	-0.159	-0.203	0.032
	Learning technique				-0.036	-2.11	0.017	-0.106	-0.172	0.018
									$\Sigma \beta \times r$	0.05
	Rational Numbers & exponents	0.27	7.7	18.58	-0.074	-3.54	0.021	-0.176	-0.239	0.042
	Learning technique				-0.54	-3.07	0.017	-0.153	-0.225	0.034
									$\Sigma \beta \times r$	0.076

Achievement of Prerequisites in Mathematics is significantly influenced (8.1%) by nature of content (4.8 %) and learning technique (3.3 %) [$R=0.286$, $F=19.95$ for ($df=2$), $p<.01$]. Evidently, nature of mathematics content has higher percent influence on achievement in mathematics than difficulties arising from learning technique and teaching learning process.

Achievement in Basic operations is significantly influenced (9.3%) by nature of content (5.4%) and learning technique (3.9%) in mathematics [$R=0.305$, $F=22.93$ for ($df=2$), $p<.01$]. Evidently, nature of mathematics content has higher percent influence on achievement in mathematics than difficulties arising from learning technique and teaching learning process.

Achievement in Daily Mathematics is significantly influenced (3.6%) by the difficulties sourcing from teaching learning process [$R=0.305$, $F=22.93$ for ($df=1$), $p<.01$] but neither by nature of content or difficulties sourcing from teaching learning process which were found to influence achievement in areas like basic operations, algebra and geometry.

Achievement in Algebra is significantly influenced (6%) by nature of content (3.7 %) and learning technique (2.3%) in mathematics [$R=0.245$, $F=14.33$ for ($df=2$), $p<.01$]. Evidently, nature of mathematics content has higher percent influence on achievement in mathematics than difficulties arising from learning technique and teaching learning process.

Achievement in Geometry is significantly influenced (5%) by nature of content (3.2%) and learning technique (1.8%) in mathematics [$R=0.225$, $F=11.91$ for ($df=2$), $p<.01$]. Evidently, nature of mathematics content has higher percent influence on achievement in mathematics than difficulties arising from learning technique and teaching learning process.

Achievement in Rational Numbers & exponents is significantly influenced (7.6%) by nature of content (4.2%) and learning technique (3.4%) in mathematics [$R=0.277$, $F=18.58$ for ($df=2$), $p<.01$]. Evidently, nature of mathematics content has higher percent influence on



achievement in mathematics than difficulties arising from learning technique and teaching learning process.

Conclusion

Mathematics is the most difficult subject for secondary school students

Mathematics is perceived as significantly more difficult than all other school subjects namely Hindi, English, Physics, Social Science, Chemistry, Biology, IT, Malayalam I and Malayalam II.

Student achievement of prerequisites in secondary school mathematics is deficient

Students have only less than satisfactory level of prerequisite achievement in mathematics; especially, students achieve below 50% in the areas like rational numbers and exponents and algebra. In areas like basic operations, daily mathematics and geometry achievement is not at satisfactory level. Twenty-five percent of students have acquired only 1/3rd of the prerequisite achievement in mathematics and more than 50 % fails to acquire half of the pre requisite for learning mathematics in standard nine.

Need for Regularity in Attending Classes, Toughness of concepts and Need for external support are the major sources of difficulty

All the 12 identified factors are perceived as the source of difficulty in learning mathematics by secondary school students. Need for regularity in attending classes, toughness of concepts and need for external support are the major sources of difficulty. Less indexed reasons for difficulty are uselessness in daily life and prevalence of symbols and notations.

Student difficulty with mathematics sources from factors in nature of content, teaching-learning, and learning environment at school and home

Reasons perceived as the source of difficulty in learning mathematics are reducible into three factors viz. Nature of mathematics content, teaching learning process and learning techniques. Reasons for difficulty sourcing from nature of mathematics content are number of concepts, prevalence of symbols and notations, difficulty in understanding questions, toughness of concepts and need to learn unfamiliar words. Reasons for difficulty sourcing from the factor teaching learning process are uselessness in daily life, need for strenuous attention, need for regularity in attending classes, need for external support and need for precision in understanding. Reasons for difficulty sourcing from the factor learning techniques are need for rote learning and need for repeated practice.

Student Perception of Difficulty in learning Mathematics Relates to their Beliefs about Nature of Mathematics

Correlational analysis revealed that the three factors of nature of school mathematics correlate with perceived difficulty in learning mathematics. Both nature of content and teaching learning process have significant positive low correlation with perceived difficulty in learning mathematics whereas learning technique has significant, positive but negligible correlation with perceived difficulty in learning mathematics.

Belief about Nature of Content Influence Achievement in Mathematics than Teaching - Learning Factors

Overall achievement in mathematics and achievement in its component areas like Basic operations, Geometry, Rational Numbers & exponents and Algebra are influenced more by difficulties arising from nature of content than difficulties arising from teaching learning process and learning technique. Achievement in daily mathematics is influenced by difficulties arising out of teaching learning process.

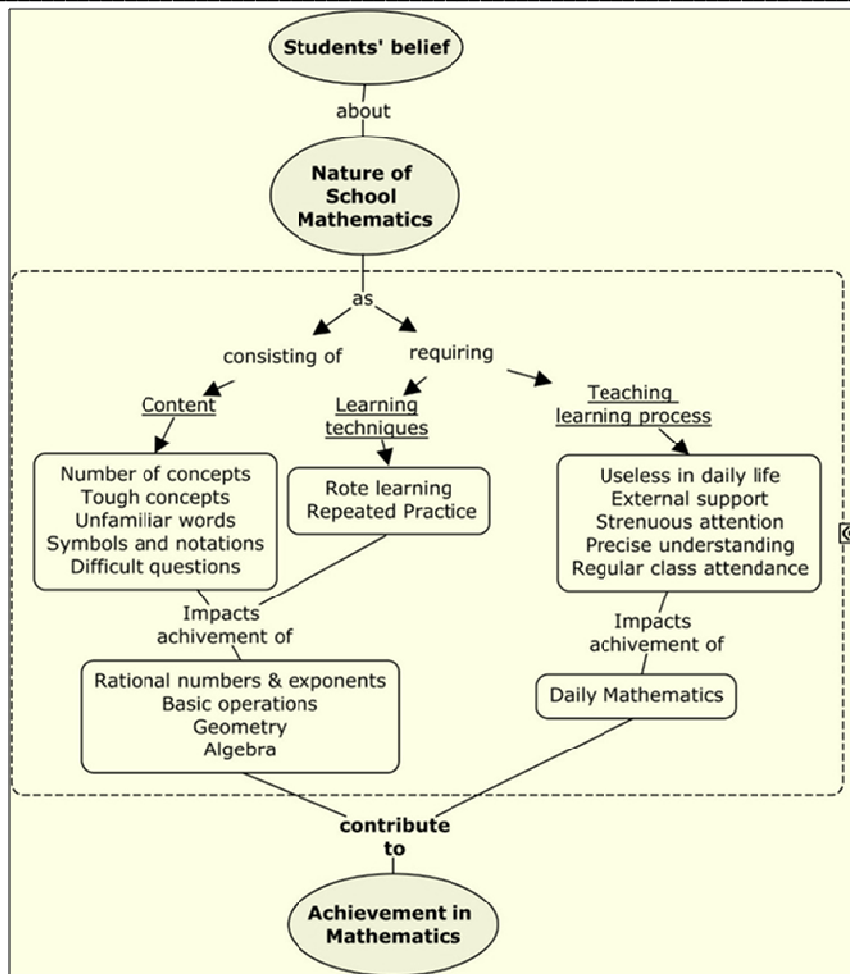


Figure 2: Influence of student beliefs about nature of mathematics on their mathematics achievement

Students' belief about nature of mathematics influence achievement in mathematics. Achievement in areas of mathematics viz. Rational numbers & exponents, basic operations, geometry and algebra is influenced by student's beliefs about nature of school mathematics as consisting of number of concepts, tough concepts, unfamiliar words, symbols and notations and difficult questions. Belief about nature of mathematics as requiring learning techniques like rote learning and repeated practice also influences achievement in the aforementioned areas. Belief about nature of mathematics as requiring teaching learning process viz. Useless in daily life, external support, strenuous attention, precise understanding and regular class attendance influences achievement in daily mathematics.

Implications

Result of this study testifies that mathematics is the most difficult subject for secondary school students. Their achievement of prerequisites for learning mathematics at this level is deficient. Students perceive difficulty in nature of mathematics content, its teaching-learning process and learning environment. Learning environment at home also contribute to sense of difficulty with mathematics learning. It is seen that difficulties arising from nature of mathematics content influence student achievement in mathematics more than other apparent factors in teaching - learning. Learning the prerequisites in the mathematics areas like basic operations, geometry, rational numbers & exponents and algebra is suffered more by difficulties arising from nature of content than difficulties arising from teaching learning process and learning technique.



Students' perceived difficulty in learning mathematics is significantly affected by their belief about nature of mathematics. Beliefs about the nature of mathematics should be reformed. Giving due importance to the rules, procedures in mathematical calculations will make the students' think that mathematics is a subject to be rote learned and there is nothing interesting in mathematics. Teachers should make the student conceive mathematics as a way of thinking, as a logical system and not as rules and formulae to remember.

Findings indicate that difficulties in achieving Mathematical concepts and skills can be remedied through adaptation in teaching learning to a substantial extent. Achievement in daily mathematics concepts is not affected by nature of content and students' learning technique as much as in other areas of maths like Basic operations, Geometry, Rational Numbers and Exponents and Algebra as well as maths in general. This suggest that relating mathematics concepts and techniques to daily life terms and situations may help learners in easing the difficulties sourcing from Number and difficulty of concepts indicated with unfamiliar words, Prevalence of symbols and notations, and hence their dependence on rote learning and drilling which may be causing learners difficulty in understanding questions.

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